ARtour: Augmented Reality-Based Game to Promote Agritourism

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Abstract. Agritourism is an extension of ecotourism, which encourages visitors to experience agricultural life at firsthand. The growing interest in this industry worldwide poses new challenges to the environment. Traditional tourism models have somehow endangered local biodiversity and, consequently, it is necessary to promote new models that include education. Eco-education is commonly conducted through passive learning approaches within educational institutions, which often result in poor student performance in real life. Therefore, it is necessary to generate active methodologies to enrich learning experiences. Augmented Reality holds the power to add multiple benefits to the learning processes. Accordingly, this study introduces "ARtour". ARtour combines an Augmented Reality experience with on-site experiences to learn about agritourism while encourages tourists to maintain responsible environmental behavior. The project considers two outdoor learning scenarios: aquaponics and subsistence crops. We posit that ARtour will enhance outdoor learning experiences and will be a useful guide to promote agritourism.

Keywords: Agritourism · Augmented reality · Eco-education
Ecotourism

1 Introduction

Agritourism is form of ecological tourism of growing interest around the world. It includes a wide variety of activities such as farm stays, bed-and-breakfast, pick-your-own produce, agricultural festivals, farm tours, and others [1]. Weaver and Fennell [2] provided a widely accepted definition of agritourism as rural enterprises which incorporates both a working farm environment and a commercial tourism component. This industry has experienced a rapid growth in the last two decades [3], posing new opportunities and challenges for natural and social environments. If properly planned and implemented, agritourism can generate positive impacts on nature and communities. Among other benefits of agritourism, we can find income generation, employment opportunities, a stronger economy, and environmental education. Some studies have

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found that farmers who participate in agritourism activities are likely to obtain higher income levels than farmers who do not undertake such activities [4–6].

However, like other forms of tourism, environmental degradation is a potential problem of agritourism, which highlights the need to promote sustainable tourism models [7–9]. These models aim to ensure the balance between economic development and nature conservation and must include eco-education as an important component [10].

Eco-education is present in educational programs around the world. However, it is often conducted through passive teaching methodologies within the classrooms and occasional field trips are reduced to a sightseeing. These strategies do not encourage students to develop interest for ecological education, which usually results on poor student performance in real life [11, 12]. Many studies have found that learning processes become more significant when students develop feelings on the subjects they are taught [13–15]. That is, for knowledge to be meaningful for students, they need to feel motivated and develop emotional attachment. Therefore, it is important to consider active teaching methodologies that enhance real environment experiences to support the learning processes.

Augmented Reality (AR) is an important technology that has been successfully implemented in many fields [16, 17]. This technology helps enrich education by transforming passive learning materials into interactive multimedia learning materials [18–21]. Since the integration of AR technologies into mobile devices [22], the development of AR applications to support learning has rapidly increased and has effectively taken root in educational settings [21, 23, 24]. Caudell and Mizell [25] introduced the term "Augmented Reality" to describe the group of technologies that allow users to augment the visual field through the use of heads-up display technologies. However, current AR systems involve not only the sense of sight but also all the other senses. In this way, Akçayir and Akçayir [23] proposed a wider definition of AR as a technology that overlays virtual objects into the real world.

The integration of AR systems into educational environments, provides multiple benefits that have been identified by different studies. These studies have concluded that learning gains and motivation are the two most reported advantages of AR systems for education [19, 21, 23]. Another important advantage reported by the studies, has to do with the fact that the integration of AR systems into mobile devices favors "mobile learning" [24]. Mobile learning allows learning processes to be carried out in outdoor learning environments, providing learners with different strategies to acquire the knowledge.

This paper presents an Augmented Reality-based game to promote agritourism named "ARtour". The project is in an early stage of development and includes the design, implementation and validation of the system through outdoor learning experiences at the final stage. ARtour is a wise farmer, who introduces basic concepts of agritourism and at the same time encourages tourists to maintain responsible environmental behavior. In addition, this research proposes to identify the impact of the ARtour system on the users learning effectiveness, addressing the following research questions (RQ):

RQ1: What is the effect of an augmented reality-based educational game on users learning gains in real-world observations?

RQ2: Are there statistically significant differences in the users' motivation according to the learning scenario they use?

RQ3: What is the degree of user satisfaction after using the ARtour application in outdoor learning scenarios?

The project considers two outdoor learning scenarios: (1) Aquaponics and, (2) Subsistence crops. To evaluate the effectiveness of the system, we propose two case studies (one per learning scenario). To identify the effect of an augmented reality-based educational game on users learning gains (RQ1), we propose to evaluate the Effect Size (ES) of ARtour on the learning effectiveness of the users. In this context, learning effectiveness is defined as the improvement in a user's learning between the beginning and the end of the intervention through the AR application. Likewise, "user" refers to the "tourist" who participates in the field trip. To evaluate users' motivation (RQ2) we propose the motivational measurement instrument Instructional Materials Motivation Survey (IMMS) [27]. Finally, to measure the degree of user satisfaction, we propose a satisfaction survey that uses a 7-point Likert scale.

2 Related Work

Many studies have found that the integration of AR systems into educational environments adds multiple benefits to teaching-learning processes. A literature review study conducted by Garzón et al. [21], analyzed 50 studies published between 2011 and 2017 (40 case studies and 10 literature review studies. This review analyzed the reported advantages and challenges of AR systems for education. Likewise, the study identified the most common target groups as well as the most common fields of education in the studies. The review found that the most reported advantages are learning gains and motivation and the most reported challenges is that AR systems are difficult for students to use. Regarding target group, the study found that most studies are focused on students from primary education, secondary education, or bachelor education. In contrast, there are some target groups such as vocational education students that have not been considered in the studies. As for fields of education, the study found that AR is most applied to teach subjects related to Natural Sciences or Mathematics. On the other hand, some fields of education such as Agriculture and Forestry have not been considered in the studies. Another important finding of the review is that only one study included aids for users with particular needs, which represents a step-back in terms of social inclusion. However, although Natural Sciences is the most common field of education in AR systems, most of these applications are related to physics, chemistry, anatomy, and biology. In contrast, applications related to eco-education are limited in number [12, 28–30], and none is related to agriculture or forestry.

3 ARtour

3.1 Concept of the Project

ARtour is a game based on AR technologies that promotes agritourism while encourages tourists to maintain responsible environmental behavior. By using ARtour, tourists will be the protagonists of an adventure that will immerse them in a journey of exploration. They will have the opportunity to learn and discover about the treasures that are hidden in Colombian landscapes. ARtour (Fig. 1), a wise farmer who represents the spirit of Colombian farmers, will guide this trip. He will provide users with the information and instructions to interact with the platform on which the experience is developed.

Fig. 1. ARtour, the wise spirit of Colombian farmers

The objective is to involve users in a story with the mission of learning about agritourism activities. They will be the protagonists of the mission and will assume an active role throughout the learning adventure. It is an immersive experience that seeks to impact users, so that they are motivated to take this experience to another level.

3.2 Description

When executing the application for the first time, the user is received by ARtour who presents himself as the guide of the experience and names the user "Explorer". ARtour is a wise farmer with the ability to communicate in multiple ways such as speech, images, texts and sounds. ARtour's guidance will allow the explorer to know beforehand the principles of agritourism and the rules that must be followed to be environmentally responsible.

The video game will involve the Explorer into a wonderful interactive audiovisual journey that stimulates his/her senses and mind. Unimaginable sounds, fantastic animals, and colorful flora are part of biodiversity that are presented in this amazing expedition. At the end of each stage of the trip, in addition to the experience and knowledge that has been collected, the Explorer becomes the creditor of a representative virtual piece. The Explorer accumulates virtual pieces as a reward which are

added to a piggy bank. Each piece has a magical power and can be used to access other digital content to learn additional information about the treasures of Colombian agriculture.

4 Learning Scenarios

The ARtour project comprises two initial learning scenarios: (1) Aquaponics and (2) subsistence crops. Further projects will expand the experience, including other forms of agriculture.

4.1 Aquaponics

Aquaponics combines aquaculture (raising fish) and hydroponics (the cultivation of plants without soil) to produce fish and plants together in a single integrated system [31]. The implementation of these systems in Colombia increased over the last decade and became an important component of Colombian government's intention to increase food self-sufficiency of farmers.

It is estimated that the volume of production varies between 25–35 kg/month of fish and between 45–50 kg/1.5 month of vegetables for an aquaponic system of 16 m^2. This supposes a large extent of the monthly food requirement of a family of 4–6 people. Furthermore, surplus production volumes can be marketed to generate additional revenue.

ARtour gives the Explorers basic information about the main functions of an aquaponic system. The trip consists of four stages. The first stage explains basic information about aquaculture. The second stage explains basic information about hydroponic systems. The third stage explains how these two systems are integrated into a single system and, finally, the fourth stage gives important information about the rules of responsible behavior to apply when interacting with this type of system. When the Explorer finishes the experience, he/she can exchange the accumulated credit into new information. This information is related to the process of construction of aquaponic systems.

4.2 Subsistence Crops

Subsistence agriculture is a self-sufficiency farming system that farmers grow to use or eat themselves and their families, rather than to sell [32]. According to the Food and Agriculture Organization (FAO) of the United Nations, Colombia is one of the countries with the greatest potential for expanding land for agricultural use in the world. Accordingly, the Colombian government and the former guerrilla group of the Farc, presented a plan that seeks to replace 50000 hectares of illicit crops with subsistence crops. This initiative has to objectives: (1) to reduce the number of illicit crops in Colombia and (2) to secure food self-sufficiency of Colombian farmers.

ARtour gives the Explorers basic information about the main functions of a Subsistence crop. The trip consists of four stages. The first stage explains basic information about subsistence agriculture. The second stage explains what type of food can be

grown in a subsistence crop according to the climatic conditions and the size of the crop. The third stage gives important information about the rules of responsible behavior to apply when interacting with this type of system. When the Explorer finishes the experience, he/she can exchange the accumulated credit into new information. This information is related to the process implementing urban subsistence crops.

5 Case Studies

We propose to conduct two case studies, one per learning scenario, each of which will be carried out in a locality of the province of Antioquia, Colombia. To assess the effectiveness of the system, we propose a quasi-experimental research structure that includes quantitative and qualitative methods.

5.1 Participants

Each case study will adopt vocational education students as a target group. Vocational education students refers to students who have finished secondary school but are not willing to enroll in a university [33]. These students have been labeled as promising research partners for validation and for demonstrating the possibilities of AR learning scenarios [34]. However, as many literature review studies have reported [20, 21, 23], these students have barely been taken into account as a target group in AR applications. The study by Garzón et al. [21], emphasizes the importance of the inclusion of these unexplored target groups to benefit such students from the affordances that AR systems adds to the learning processes.

Each case study will have an approximate number of 50 students and will be made up of experimental and control groups. Both groups will be trained by the same instructor to eliminate the confounding factors on the experimental results of different personalities, teaching styles, and teaching methods [35].

5.2 Experimental Instruments

The search includes as experimental instruments the pre-test, the post-test, the motivational measurement instrument IMMS, and the satisfaction survey. The pre-test aims to identify previous knowledge of users about agritourism. This test is taken by students from experimental and control groups. Users of both groups take the post-test at the end of the experience. This test aims to identify the knowledge acquired by users after having been trained by either of the two methodologies. The credibility of both the pre-test and the posttest, will be assessed using the Kuder-Richardson reliability formula.

To assess the impact of the learning approaches on the students' learning motivation, we propose the motivational measurement instrument IMMS. It includes 36 questions in 4 subscales, scored using a 5-point Likert scale. Each level ranges from "strongly disagree" (1) to "strongly agree" (5). The main components in the IMMS are attention, relevance, confidence, and satisfaction. Finally, the satisfaction survey aims to measure the degree of user satisfaction when using the ARtour application.

It consists of 10 statements that used a 7-point Likert scale. Each level ranges from "strongly disagree" (1) to "strongly agree" (7).

6 Results

As explained above, the project is at an early stage. Therefore, this section does not present obtained results but results that are expected after the validation of the project.

6.1 RQ1: What Is the Effect of an Augmented Reality-Based Educational Game on Users Learning Gains in Real-World Observations?

To guarantee equivalent prior knowledge of the students in the experimental and control groups, a t-test is proposed in terms of their pre-test grades. Next, to identify the outcomes of the students when using different learning methodologies, a t-test is proposed to compare the post-test grades between the two groups. Finally, to measure the effect of the ARtour System on the learning effectiveness of the users, we propose to calculate the ES based on Cohen's *d* ES using the following formula:

$$ES = \frac{\left(\bar{X}_{1\_post} - \bar{X}_{1_{pre}}\right) - \left(\bar{X}_{2\_post} - \bar{X}_{2\_pre}\right)}{SD_{post}} \quad (1)$$

Where, $\bar{X}_{1\_post}$ and $\bar{X}_{1\_pre}$ are the mean scores of the post-test and pre-test of the experimental group, respectively. $\bar{X}_{2\_post}$ and $\bar{X}_{2\_pre}$ are the mean scores of the post-test and pre-test of the control group, respectively. Finally, SD_{post} is the pooled standard deviation for the post-test:

$$SD_{post} = \sqrt{\frac{\left(n_{2\_post} - 1\right)S^2_{2\_post} + \left(n_{1\_post} - 1\right)S^2_{1\_post}}{\left(n_{2\_post} + n_{1\_post} - 2\right)}} \quad (2)$$

Where n_{2_post} and n_{1_post} are the sample sizes of the experimental and control groups, respectively. S_{2_post} and S_{1_post} are the standard deviations for the experimental and control groups respectively for the post-test.

6.2 RQ2: Are There Statistically Significant Differences in the Users' Motivation According to the Learning Scenario They Use?

To evaluate users' motivation (RQ2) we use the motivational measurement instrument Instructional Materials Motivation Survey (IMMS) [27]. This instrument measures learner motivation following the ARCS model and is particularly relevant to evaluate the impact of technology as a motivational factor in learning [36].

6.3 RQ3: What Is the Degree of User Satisfaction After Using the ARtour Application in Outdoor Learning Scenarios?

An additional test is proposed to be applied to users, once the educational experience is completed. It is a satisfaction survey (Table 1) validated and used in other investigations [37] and modified to be applied in this research.

Table 1. Satisfaction survey.

Question/affirmation
1. I am comfortable using the application
3. It is easy to navigate within the application
4. The information displayed in the application is accurate
5. The application has given me a positive impression about agritourism
6. The application has given me important information for my learning
7. The graphic design of the application is visually appealing
9. I was given enough information for the use of the application
10. I like the information that shows the application

The users are requested to rate the degree of agreement with each of the 10 statements based on a Likert type scale with 7 levels. Each level ranges from "strongly disagree" (1) to "strongly agree" (7). This instrument will allow us to know the perception of the users, their feelings and the degree of satisfaction with the use of the proposed system. In addition, to gain more qualitative feedback, we propose to conduct a short an informal interview to some of the users of the application.

7 Conclusion and Future Work

We posit that the use of ARtour will improve outdoor learning experiences and allow tourists to learn basic principles of agritourism. ARtour will motivate and facilitate the learning experience of tourists while having fun playing an AR game. ARtour intends to extend the concept of agritourism to a broader concept of Eco-agritourism, by showing tourists the importance of protecting and conserving of nature. In addition, ARtour encourages the tourists to build their own agricultural systems, if possible at their own spaces. Further research is pretended to be developed along with the ministry of tourism in Colombia. This research will focus on developing a wider set of options for tourist to visit and learn about agritourism activities.

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